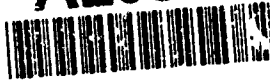


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ELECTRONIC TRAJECTORY
MEASUREMENTS GROUP

IRIG STANDARD 253-93

**MISSILE ANTENNA PATTERN COORDINATE SYSTEM
AND DATA FORMATS**

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**MISSILE ANTENNA PATTERN COORDINATE SYSTEM
AND DATA FORMATS**

AUGUST 1993

Prepared by

**ELECTRONIC TRAJECTORY MEASUREMENTS GROUP
RANGE COMMANDERS COUNCIL**

Published by

**Secretariat
Range Commanders Council
U.S. Army White Sands Missile Range,
New Mexico 88002-5110**

PREFACE

This standard defines requirements and sets up responsibilities and procedures for submitting airborne vehicle antenna performance characteristics to the Range Commanders Council (RCC) test ranges. Successful support of test programs requires compatibility between airborne systems and range instrumentation systems. Antenna performance characteristics are to be sent to the lead range for analysis to evaluate the proposed mission for safety and supportability. The antenna patterns, along with the trajectory, are used to establish the margin for each radio-frequency (RF) link. Additionally, the media encoded with digital information must be provided. The test ranges will not support a program without this data in the required format. Furthermore, this data is also required to satisfy range safety requirements.

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CHAPTER 1

INTRODUCTION

1.1 General, Antenna

Antenna performance data pertains to missile, space, and aerodynamic vehicles' transmitting or receiving antennas used with range data collection, missile trajectory measurements, impact predictions, communications, or flight termination systems. As used in this document, the terms missile, space vehicle, airborne, and aerodynamic vehicle are synonymous. This standard is intended to cover antennas for

- telemetry,
- pulsed radar beacons,
- continuous wave (CW) transponders,
- communication transmitters and receivers,
- command control/flight termination receivers/decoders,
- pseudo random noise (PRN) ranging systems, and
- the Global Positioning System

Antenna systems will be elliptical polarized in some direction, so tracking antenna systems are usually either circular or linear polarized in the direction of maximum gain. Elliptical polarization is the most general type for electromagnetic waves, while linear and circular polarization are special cases of elliptical polarization. To make signal strength predictions for a right (left)-hand circular-polarized tracking antenna, one corresponding right (left)-hand circular polarized antenna-measurement pattern is needed from the airborne vehicle.

When the supporting system is linear or circular polarized, an absolute minimum of four antenna measurement patterns are required; however, six antenna measurement patterns are preferred. The six preferred measurements are designated as right-hand circular, left-hand circular, linear theta, linear phi, linear 45°, and linear 135°. The use of six patterns will give better assurance of data quality as compared to the minimum requirements of four.

If the minimum of four measurement patterns are obtained, two of the measurement patterns shall be right-hand circular and left-hand circular, because most range systems are compatible with these polarizations. The other two linear polarizations must be one from the theta or phi set, and one from the 45 or 135° set so that the two linear polarized components are separated by 45°. The minimum four-pattern sets are permitted

because of theoretical relationships that exist between the various patterns; however, because of errors existing in any measurement process, the theoretical relationships may not hold for the actual measurements. The six pattern set allows better compensation for these inherent measurement errors.

Certain antenna configurations have an inherent phase front distortion characteristic and have a greater possibility of introducing errors in range, azimuth, and elevation of the ground based antenna/receiver. Because of these possible tracking errors, the individual test range may also require phase measurements to be made and recorded. Phase measurement requirements will be decided by the individual range for a specific airborne antenna system and vehicle characteristics. Each individual test range has a handbook describing its range instrumentation system. The handbook can be obtained from that particular range.

1.2 Definitions

Important terms related to these procedures are listed in the following subparagraphs.

1.2.1 Antenna (Radio). A device capable of radiating or receiving radio-frequency electromagnetic energy.

1.2.2 Antenna, Isotropic (Radio). A hypothetical device that radiates or receives radio-frequency energy equally well in all directions; that is, the power radiated or received by an isotropic antenna is completely independent of direction from the antenna. Although an antenna of this nature cannot be constructed, it serves as a convenient mathematical reference.

1.2.3 Antenna Pattern. A representation of an antenna's radiation or receiving characteristics in geometric space. The radiation or receiving characteristics are normally stated as contours of equal gain or in a numerical matrix relative to a convenient reference. For mathematical convenience, the isotropic level is normally used as this reference.

1.2.4 Antenna Power Gain. The antenna power gain in a given direction is 4π times the ratio of the radiation intensity in that direction to the total power delivered to the antenna. When the gain of an antenna is given with no reference to direction, it assumes the maximum gain value.

1.2.5 Attenuation, Radio-Frequency. The decrease in amplitude of a radio-frequency wave as it passes through a medium. Attenuation is usually expressed in decibels.

1.2.6 Attitude, Vehicle. The axial positions of a vehicle in reference to a fixed coordinate system. Usually, the attitude of a vehicle is related to a vehicle's trajectory by the direction of its pitch, roll, and yaw axes; the trajectory is, in turn, related to an earth-fixed coordinate system.

1.2.7 Axis, Roll. An agreed, predefined vehicle axis. This axis, usually identical to the vehicle's longitudinal axis, has origin at the vehicle's nominal center of gravity with its positive direction towards a point on the leading end or nose. Once defined, this axis remains fixed with respect to the vehicle body (see figure 3-4).

1.2.8 Axis, Yaw. A line through the vehicle's nominal center of gravity and perpendicular to the roll axis. This axis (also called the "normal" axis) may be arbitrarily defined or may be related to the vehicle's normal orientation with respect to a reference coordinate system. The following comments give the normal position of the yaw axis under the respective condition.

- The physical body location of the yaw axis of an ill-defined spinning body may be completely arbitrary.
- In the case of a wing-supported aircraft or missile in straight and level flight with respect to the earth's surface, the yaw axis is in line with the gravitational force vector. The positive part is down in the direction of the gravitational force.
- In the case of a ballistic missile or rocket, the yaw axis is normally associated with the trajectory, except for minor deviations, and is in the plane in which the vehicle programs about the pitch axis. Once defined, the yaw axis remains fixed with respect to the vehicle's body (see figure 3-4).

1.2.9 Axis, Pitch. A line through the vehicle's nominal center of gravity perpendicular to both roll and yaw axes. The pitch axis (also called the "lateral" axis) forms a third ordinate of the vehicle's orthogonal coordinate system. For straight and level flight of the vehicle with respect to the earth's surface, the pitch axis is in the horizontal plane. When viewing the vehicle from its tail or aft position, the positive part of the pitch axis is to the right when the positive part of the yaw axis is down (see figure 3-4).

These three axes with their common origin define the orthogonal basis (coordinate system) for the vehicle. Once established for a particular vehicle, the spherical coordinate angles ϕ and θ are defined relative to these axes. Also, the trajectory information for each operation provides direction cosine information that defines the nominal orientation of these axes in earth-centered coordinates. All of this information must be internally consistent throughout the program.

1.2.10 Center of Gravity. A point at which the mass of the entire body may be regarded as being concentrated. Also called Center of mass.

1.2.11 Circular Polarization. A uniform plane wave where the variation of amplitude with time of the electric field components parametrically defines the locus of a circle within the plane. The amplitude of the two electric field components is equal, and the electrical time phase angle (δ prime) between the two components is 90° .

1.2.12 Cross Polarization. The component of the electrical field vector normal to the desired polarization component.

1.2.13 Decibel (dB). A unit of relative power. The decibel ratio between two power levels, P_1 and P_2 , is defined by the relation $\text{dB} = 10 \log_{10} (P_1/P_2)$. The ratio between two magnitudes of voltage, current, or field strength may be stated in decibels by proper reference to the basic definition in terms of power.

1.2.14 dBm. A unit used to express an arbitrary power level in terms of its decibel ratio to a reference level of 1 milliwatt.

1.2.15 Delta (δ). The electrical time phase angle between the two linear polarized components, E_ϕ and E_θ , of an electric wave.

1.2.16 Delta Prime (δ'). The electrical time phase angle between the two circular polarized components, E_{RH} , and E_{LH} , of an electric wave.

1.2.17 Electric Field. The vector force field set up in the vicinity of a system of electric charges. The strength of the static field at a point is stated as the force per unit charge of a stationary positive test charge, provided the test charge is so small that it does not disturb the original charge distribution of the system. This force has a definite magnitude and direction for each possible location of the test particle. These force vectors define the field.

1.2.18 Electromagnetic Field. A vector force field produced by the arbitrary motion of electric charges. The electromagnetic (EM) field at a point is described by separate electric and magnetic force vectors; the complex relation between the two fields (and the currents and charges producing them) is given by a set of partial differential equations known as Maxwell's equations.

1.2.19 E_{LH} . The left-hand circular polarized component of an electric wave.

1.2.20 Elliptical Polarized Wave. A uniform plane wave where the variation of amplitude with time of the electric-field components parametrically defines the locus of an ellipse within the plane. Circular polarized waves and linear polarized waves are special cases of the more general elliptical polarized wave.

1.2.21 E_ϕ . Component of the electric vector in the ϕ direction.

1.2.22 E_θ . Component of the electric vector in the θ direction.

1.2.23 E_{RH} . The right-hand circular polarized component of an electric wave.

1.2.24 Gain, Directional (Antenna). The same as antenna power gain except the total is the total power radiated from the antenna instead of the total power delivered to the antenna.

1.2.25 $g(\theta, \phi)$. Total directional antenna power gain as a function of coordinate angles θ and ϕ .

1.2.26 g_{RH} . This gain is the same as the antenna power gain except the radiation intensity corresponds only to that particular polarization. Consequently, this gain must be less than or equal to the antenna power gain. The subscript defines the elliptical polarized transverse electromagnetic wave in which the rotation of the electric field vector is clockwise for an observer looking in the direction of propagation.

1.2.27 g_{LH} . This gain is the same as the antenna power gain except the radiation intensity corresponds only to that particular polarization. Consequently, this gain must be less than or equal to the antenna power gain. The subscript defines the elliptical polarized transverse electromagnetic wave in which the rotation of the electric field vector is counterclockwise for an observer looking in the direction of propagation.

1.2.28 Left-Handed (Counterclockwise) Polarized Wave. An elliptical polarized transverse electromagnetic wave in which the rotation of the electric field vector is counterclockwise for an observer looking in the direction of propagation.

1.2.29 Linear Polarized Wave. A electromagnetic wave whose electric and magnetic field vectors always lie along fixed lines at a given point.

1.2.30 Phase Angle. The measure of the progression of a periodic wave in time or space from a chosen instant or position. The phase angle of a field quantity, voltage, or current at a given instant of time.

1.2.31 Phase Difference (Psi). A change of phase angle with transmission. The difference in phase between two sinusoidal functions having the same periods.

1.2.32 Phi(ϕ) Angle. Angle measured in the plane of the yaw and pitch axes. When viewed from the positive roll axis, phi is measured positive counterclockwise from the positive yaw axis.

1.2.33 Phi(ϕ) Polarization. A component of an electric-field vector linear polarized in the phi direction.

1.2.34 Phi(ϕ) Direction. An arbitrary point within the coordinate system defined by the roll, pitch, and yaw axes. The distance from the origin is held constant, and the angle theta is held constant, but phi is allowed to vary. The variance forms a curve in space, and the phi direction is the unit vector tangent to this curve at the arbitrary point. This vector is perpendicular to the theta direction.

1.2.35 Pitch. An angular movement about the pitch axis.

1.2.36 Pitch Angle. An angular displacement about the pitch axis between the roll axis and a reference plane normal defined by a line tangent to the vehicle's trajectory. A line perpendicular to the tangent line and horizontal to the earth's surface or a similar reference surface. The pitch angle's positive direction is clockwise when viewing the vehicle in the direction of the positive pitch axis.

1.2.37 Pitch Plane. A plane normal to the pitch axis and defined by the roll and yaw axes.

1.2.38 Plane. A flat surface; one whose radii of curvature are infinite at all points.

1.2.39 Plane Wave. A wave in which the wave fronts are everywhere; parallel planes normal to the direction of propagation.

1.2.40 Polarization. A term used to describe the behavior of the electric vector in a fixed plane normal to the direction of propagation as a electromagnetic wave moves through a medium.

1.2.41 Program, Roll. A planned movement about a vehicle's roll axis.

1.2.42 Program, Pitch. A planned movement about a vehicle's pitch axis.

1.2.43 Program, Vehicle. The pre-established flight events to be followed by a vehicle. The program commands all critical functions required for the vehicle to accomplish its objective.

1.2.44 Program, Yaw. A planned movement about a vehicle's yaw axis.

1.2.45 Radio Wave. A common name for electromagnetic radiation in the radio portion of the spectrum from approximately 3×10^3 to the upper limit of 3×10^{11} hertz.

1.2.46 Radiation Intensity. The power per unit radiated in a given direction.

1.2.47 Right-Handed (Clockwise) Polarized Wave. An elliptical polarized transverse electromagnetic wave in which the rotation of the electric-field vector is clockwise for an observer looking in the direction of propagation.

1.2.48 Roll. An angular movement about the roll axis.

1.2.49 Roll Angle. An angular displacement about the roll axis between the pitch axis and reference. Normally defined by a line tangent to the vehicle's trajectory and a line perpendicular to this tangent line and horizontal with, or parallel to, the earth's surface or a similar reference surface. Its positive direction is clockwise when viewing the vehicle from the rear in the direction of positive roll axis. The roll angle is sometimes called the "angle of bank" (see figure 3-4).

1.2.50 Roll Plane. A plane normal to the roll axis and defined by the yaw and pitch axes.

1.2.51 Spherical Wave. A wave whose equiphasic surfaces form a family of concentric spheres. At distances of many wavelengths, a spherical wave is often approximated as a plane wave.

1.2.52 Theta (θ) Angle. Angle measured in the plane defined by the roll axis and the terminus point of the phi angle. Theta is measured positive within this plane from the positive roll axis. The phi angle terminal point is within the plane of the yaw and pitch axes.

1.2.53 Theta (θ) Polarization. A component of an electric-field vector linear polarized in the theta direction.

1.2.54 Theta (θ) Direction. An arbitrary point within the coordinate system defined by the roll, pitch, and yaw axes. The distance from the origin is held constant and the phi is held constant, but theta is allowed to vary. The variance forms a curve in space and the theta direction is the unit vector tangent to this curve at the arbitrary point. This vector is perpendicular to the phi direction.

1.2.55 Tilt (τ). The relative orientation of the ellipse is established by an angle between the major axis of the ellipse and a defined reference line.

1.2.56 Uniform Plane Wave. A plane wave in which the electric and magnetic field vectors have constant amplitude over the equiphase surfaces.

1.2.57 Vertical Polarized Wave. A linear polarized wave whose electric-field vector is vertical with respect to the earth's surface.

1.2.58 Wave. Propagated disturbance, usually periodic.

1.2.59 Yaw. An angular movement about the yaw axis.

1.2.60 Yaw Angle. An angular displacement about the yaw axis between the roll axis and a reference plane normally defined by a line tangent to the vehicle's trajectory and the gravitational vector. The yaw angle's positive direction is clockwise when viewing the vehicle in the direction of the positive yaw axis.

1.3 References

MIL-A-87136	9 Jan 79	<u>Airborne General Specifications for Antennas</u>
IEEE STD 149-1979	15 Dec 79	<u>IEEE Standard Test Procedures for Antennas</u>
IEEE STD 145-1983	22 Jun 83	<u>IEEE Standard Definitions of Terms for Antennas</u>
IEEE STD 100-1984	10 Aug 84	<u>IEEE Standard Dictionary of Electrical and Electronic Terms</u>

CHAPTER 2

RESPONSIBILITIES AND PROCEDURES

2.1 Responsibilities

The lead range and range user's responsibilities are defined in the following subparagraphs.

2.1.1 Lead Range Responsibilities

The lead range will certify the range user's antenna performance characteristics for satisfying the power gain, directivity, efficiency, coverage, and phase-measurement requirements. The phase-measurement requirement must be specifically requested by the lead range, otherwise it is assumed not to be a requirement.

2.1.2 Range User Responsibilities. If the range user modifies or builds a new antenna, makes an antenna-configuration change, or changes antenna locations, the user shall furnish a link analysis between the airborne-vehicle antenna and the test-range instrumentation. The range instrumentation handbooks for each individual test range provide data about the characteristics of each range instrumentation system for use in the link analysis. The link-analysis data will be used by the range user to generate a minimum antenna specification. Range users will furnish the link-analysis data and the missile antenna performance characteristic data under the requirement stated here.

For United States Air Force ranges, user assistance may be obtained from Rome Air Development Center (RADC), an agency that conducts antenna-pattern measurements. The RADC address and phone numbers are RADC/RBC, Griffiss Air Force Base, New York 13441, Commercial: (315) 330-3076 or DSN: 587-3 76.

2.2 Procedures

The lead range and range user's procedures are defined in the following subparagraphs.

2.2.1 Lead Range Procedures. The lead range, on a timely basis, will

- evaluate the range user's compliance with the requirements of this document and, when necessary, forward a discrepancy report to the applicable project office, and

- provide the appropriate range staff offices with specific comments and recommendations relating to expected performance agreement of the vehicle-antenna characteristics with range ground-based instrumentation.

2.2.2 Range User Procedures. The range user's test agencies will furnish link analysis and antenna data in the format specified in chapter 3 to the lead range, through the applicable project office. For multiple range programs, the lead range will distribute copies to other ranges as applicable. Data will be submitted by the range user

- 12 months before first launch date for a new program, and
- 3 months before first use of a new or modified antenna, antenna configuration change, or antenna location change in any test program currently active at a national range.

2.3 Requirements and Procedures

Requirements and procedures in this document are for use by national ranges and range users.

2.4 Waivers

Waivers to the requirements of this document must be submitted to the lead range by the range user. Such requests must be submitted to the appropriate range in writing and must clearly state why a waiver is needed.

2.5 Test Notification

Before antenna measurements are made, it is mandatory that the lead range be notified in a timely manner of antenna tests to be conducted. The lead range reserves the right to witness any and all testing required by this document.

2.6 Documentation Disposition

Computer printouts and tabulated data described in this document will be considered proprietary information when requested.

CHAPTER 3

ANTENNA REQUIREMENTS

3.1 Antenna Radiation Pattern

To represent the complete radiation-pattern characteristics for setting up a link margin between two or more antennas, the general solution requires an analysis of several polarization components. The RF wave's intensity and its polarization characteristics relative to a receiving-antenna system are needed to evaluate the link margin between source and receiving antennas. The RF wave can be shown by the behavior of its electric vector which, in general, varies in amplitude in such a way that it may be represented by an ellipse as it appears to rotate at the radio frequency. All pattern measurements are typically in continuous wave. The parameters describing the ellipse are discussed in the following subparagraphs.

3.1.1 Polarization Ellipse. The polarization ellipse may be resolved into either circular or linear polarized components. The relative orientation of the ellipse (an equally important parameter) is established by an angle between the major axis of the ellipse and a defined reference line. This orientation angle is generally referred to as the "tilt" angle and is represented by the Greek letter τ (tau).

3.1.2 Radiation Characteristics. Since the wave's directional characteristics vary with change in relative attitude of the antenna (or vehicle) with respect to the ground antenna, radiation characteristics must be known over the entire spherical surface surrounding the antenna. An absolute isotropic reference value must be provided with the gain values g_+ , g_0 , g_{45} , and g_{135} furnished with the DOS data disk. Total gain and phase values (if required) must be provided on disk.

3.1.3 Circular Polarized Antenna Patterns. To completely evaluate the RF link margin between two or more antennas, the general condition requires a circular polarized set (g_{RH} , g_{LH} , and δ') for each system.

3.1.4 Antenna Pattern Orientation. The relative orientation of the polarization ellipse or the tilt angle τ can be calculated from the linear polarized amplitude components g_+ , g_0 , g_{45} , and g_{135} or calculated from a combination of circular and linear polarized amplitude components g_{RH} , g_{LH} and two linear polarized components: one 45° (in space) from the other. The amplitude components are more easily acquired than are the direct tilt

angle or electrical phase measurements. Of the two indirect amplitude techniques, the linear-component method for determining r has two distinct advantages:

- * all components for the calculation have a direct common reference, which lessens the chance of error; and

- * it provides for a cross check of data, thus ensuring better data quality standards. Therefore, the four component linear set (g_4 , g_0 , g_{45} , g_{135}) must be supplied in the same form as g_{RH} , g_{LH} .

3.1.5 Vehicle Antenna Coordinate System. Proper orientation of the E_4 and E_0 coordinates, and consequently g_4 , g_0 , in the vehicle antenna coordinate system is shown in figure 3-1. Subscripts of component designations E_{45} or g_{45} and E_{135} or g_{135} represent the angles at which these values are measured. Angles are measured from the positive E_0 direction in counterclockwise direction. Therefore, E_{45} or g_{45} is the 45° linear component, and E_{135} or g_{135} is the 135° or minus 45° component. Figure 3-1 also shows the linear component orientations in relationship to the antenna coordinate system.

3.2 Antenna Pattern Requirements

Electromagnetic waves radiated from an antenna or the receiving abilities of an antenna are never truly circular or linear polarized in all directions, namely when the antenna is placed on a cylindrical vehicle such as a missile or spacecraft. For this reason, all pattern components (g_{RH} , g_{LH} , g_4 , g_0 , g_{45} , g_{135}) are needed from range users to show the complete antenna radiation pattern characteristics. Minimum requirements are identified in paragraph 3.7.2.

3.2.1 More Than One Pattern Set for a Single Antenna System.

Often, more than one radiation pattern set is required from a single antenna system. This requirement may result from any factor that serves to markedly alter the antenna pattern. For example, changes in antenna radiation characteristics may be the result of variation of frequency required to be radiated from the antenna system, changes in vehicle configuration (for example, at staging or separation, or variations in RF propagation characteristics (for example, flame and reentry effects). Under these conditions, other pattern sets should be treated independently (such as patterns of separate antennas) with the proper identifying descriptions as stated in chapter 4.

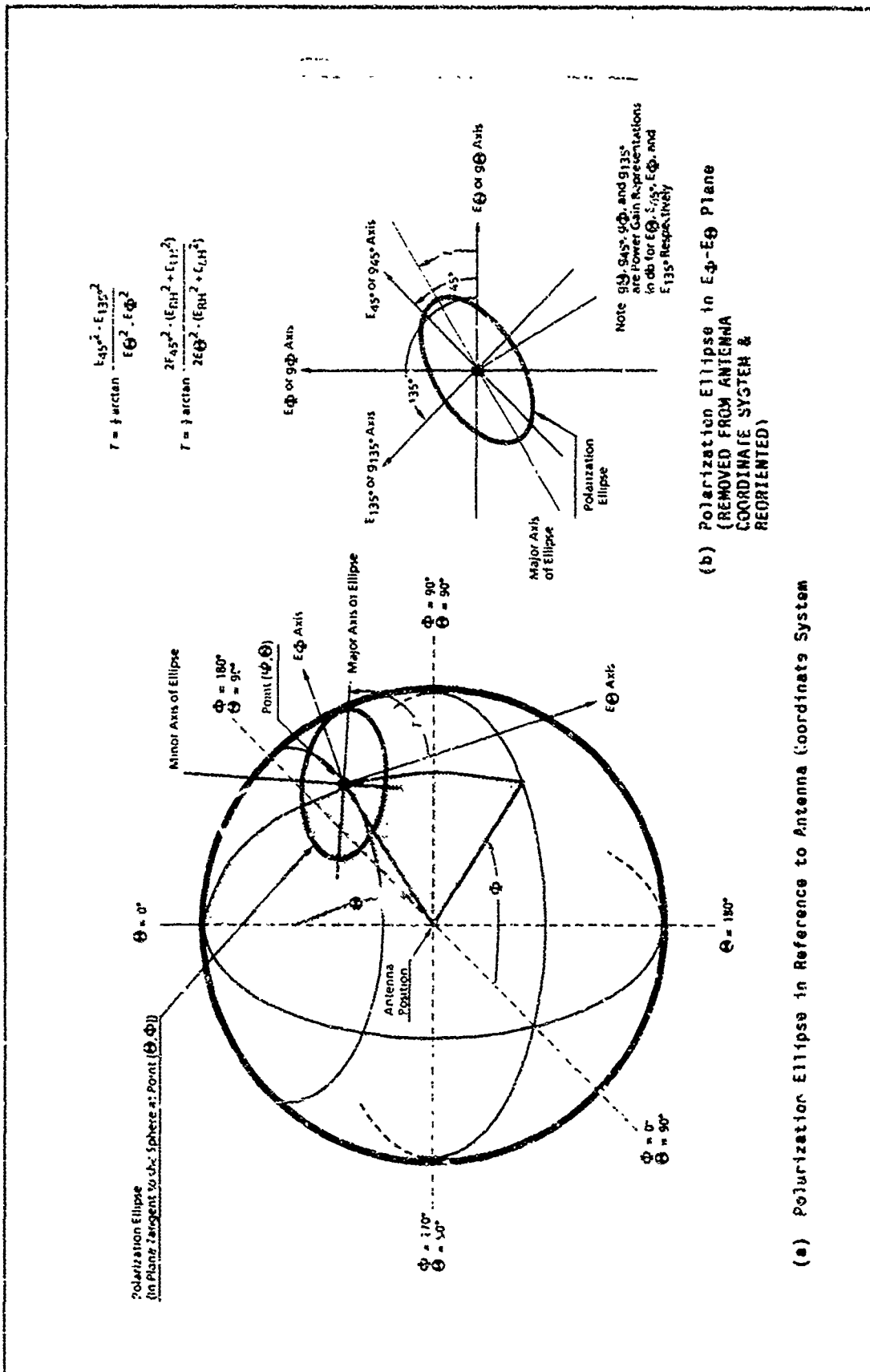


Figure 3-1. Polarization ellipse and polarization components.

3.2.2 Antenna Sketch and Location. A dimensioned drawing of the airborne antennas showing important details must be supplied by the range user. If the antenna system consists of more than one identical antenna, only one drawing need be shown. An orientation vector will be shown on each view of the antenna. The position of this vector will be shown on each view of the antenna. The position of this vector with respect to the antenna will be clearly shown. For linear polarized antennas, the orientation vector will indicate the direction of the antenna's electric field. The type of polarization, linear or circular, will be shown on the sketch if the antenna is not linear polarized. Figure 3-2 shows the direction of the orientation vector for all antennas in the system given in ϕ and θ of the spherical coordinate system presented in figure 3-2. These angles are referred to as ϕ_p and θ_p .

3.2.3 Antenna Pattern Data (Tabulation). To ensure that there is no deterioration of data or mixup of floppy disks, antenna data must be supplied in tabulated form. All information required on the disks, as outlined in chapter 4, shall be processed and submitted to the range in a graphical matrix plot. If matrix plots (field of relative gain values) are used, optional odd gain values may be used to give a contour like appearance. Figure 3-3 shows a part of the desired matrix plot. Tabulated information must be fully identified in the same manner as the floppy disks such as missile program identification, project office, frequency band, and gain reference value. Refer to paragraph 4-3, Information File Description.

3.2.4 Angular (ϕ or θ) Increments. When phase measurements are required, the angular (ϕ or θ) increments shall be no greater than 1° . With no phase requirement, the increments shall be no greater than 2° . When a lesser pattern resolution is absolutely required because of equipment limitations, matrix plots shall clearly indicate null points and values. This information will be required for antenna systems made up of more than one but less than ten discrete radiating elements with the largest inter-element spacing greater than eight wavelengths at the operating frequency. These data need not be written on the data file, but null angles and power levels must be indicated in the header file.

3.2.5 Antenna Operating Frequency. The antenna patterns will be performed at the assigned operating frequency. When possible or when assigned operating frequency is not yet known, the patterns should be performed over the designated frequency range.

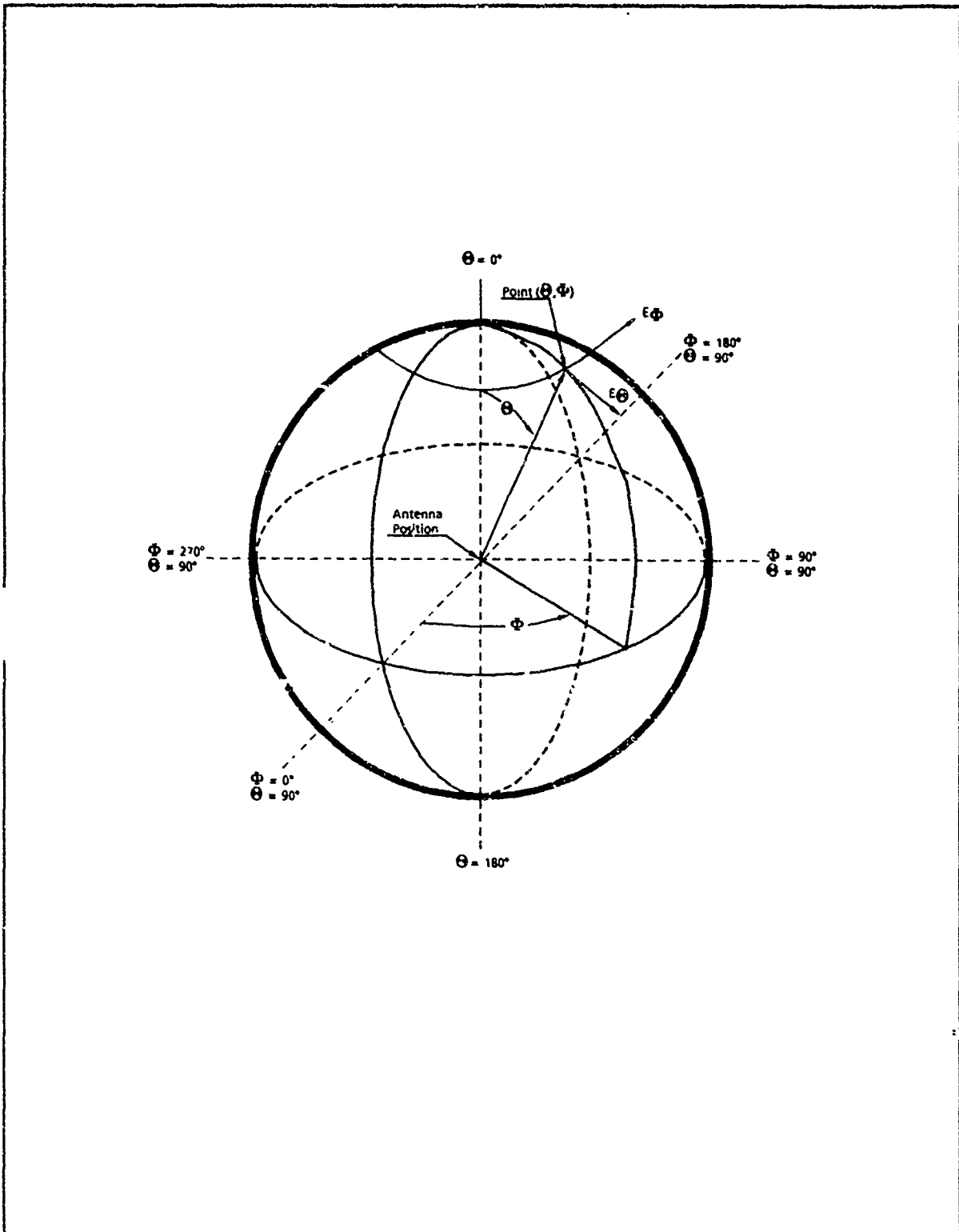


Figure 3-2. Spherical Antenna Coordinate System.

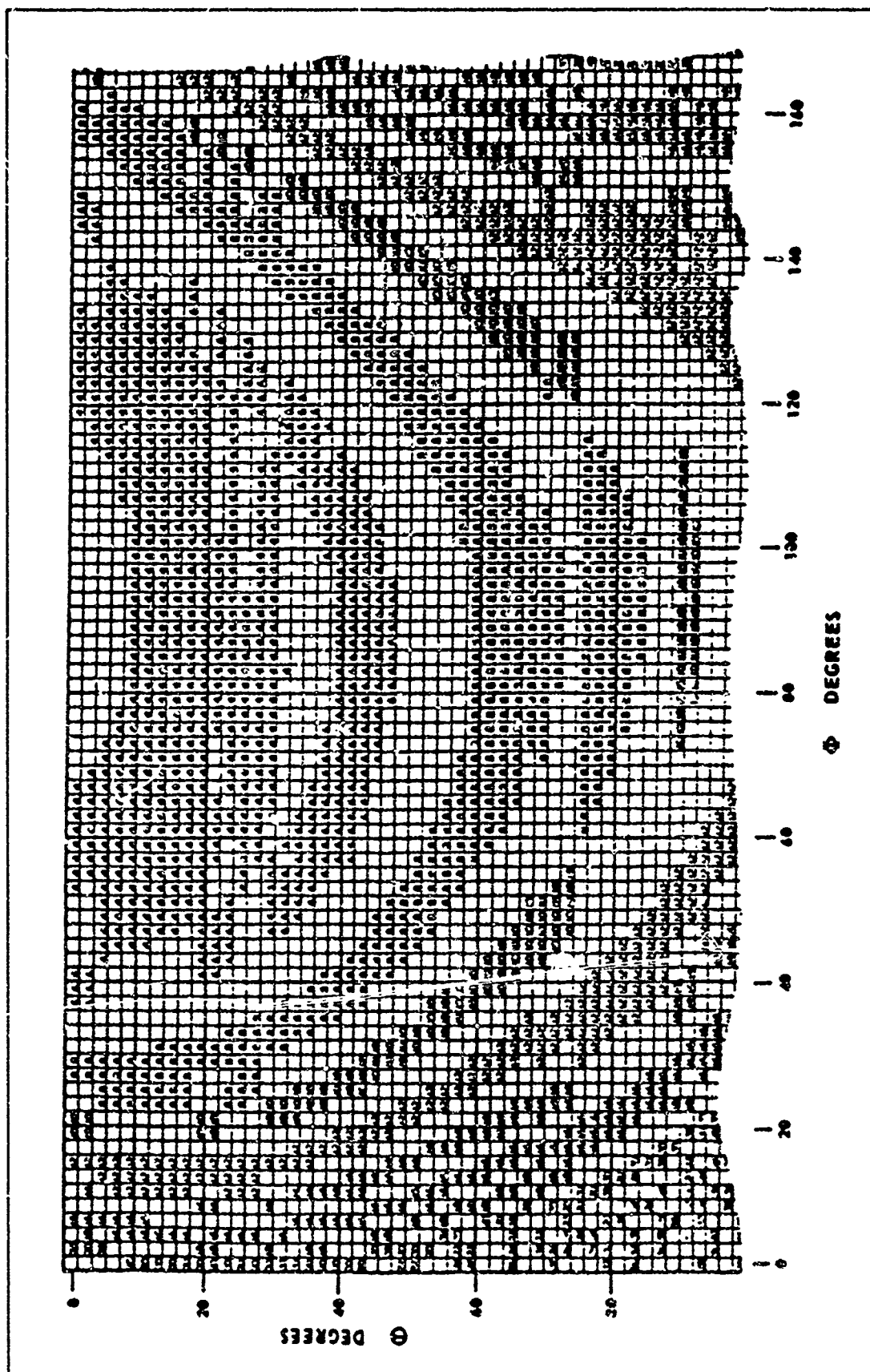


Figure 3-3. Sample of matrix antenna pattern plot.

3.3 Geometry

The missile and aerodynamic vehicle antenna geometry as shown in figure 3-4 will be used in the presentation of data required by this document.

3.4 System Parameters

The power delivered to antenna terminals and the minimum power level required at receiver antenna are discussed in the following subparagraphs.

3.4.1 Power Delivered to Antenna Terminals. For each airborne transmitter, the average or peak-power levels (dBm) at the transmitting antenna terminals shall be provided as stated in chapter 4. Only average power is required for continuous wave systems. For pulse systems, both average and peak-power levels are required. These levels are derived by subtracting transmission system losses from the power level at the transmitter output terminals (for example, line losses, losses resulting from standing waves or impedance mismatches, multicoupler losses or any loss that decreases the power level between the transmitter and antenna). Phasing networks and couplers associated with antenna arrays are considered part of the antenna system. Losses in these elements and antenna inefficiency should be included in the antenna pattern as inherent in the pattern measurement. If the power level at the transmitting antenna system varies by more than 2 dB over the frequency range of operation, significant power levels will be entered in spaces provided in the disk format. In all applicable cases, at least one power level will be entered. The method for setting up these levels shall be defined.

3.4.2 Minimum Power Level Required at Receiver Antenna. For each airborne receiving system, the minimum power level (dBm) required at the receiver antenna terminals will be noted as stated in chapter 4. In determining this quantity, allowance must be made for such parameters as bandwidth, noise figure, signal-to-noise ratio, transmission-line attenuation, impedance mismatch, multicoupler losses, and operating margin. The quantity desired is the minimum power level (dBm) required at the receiver input plus the various losses (dB) from the antenna system to the receiver input. Any losses included in the antenna patterns such as those attributed to transmission lines and multicouplers must not be accounted for again in the minimum received power level requirements. Phasing networks and couplers associated with antenna arrays are considered part of the antenna system. Losses in these elements and antenna inefficiency should be included in the antenna pattern as part of the pattern measurement. If the required minimum power level varies by more than 2 dB over the frequency range of operations, significant power levels will be entered in spaces provided in the disk formats. In all applicable cases, at least one power level will be entered.

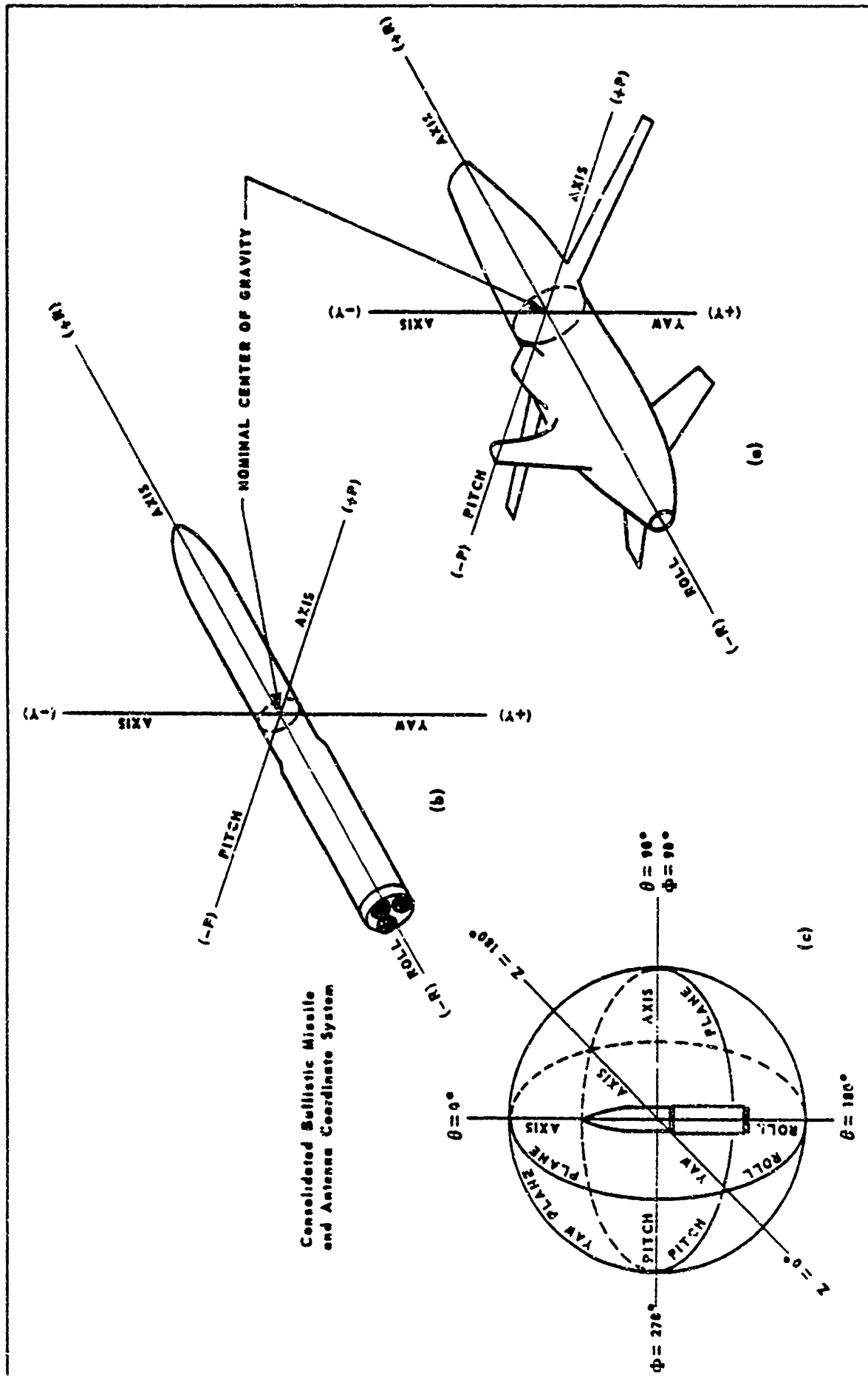


Figure 3-4. Examples of standard vehicle coordinates for ballistic and aerodynamic vehicles.

3.5 Trajectory Information

Trajectory data will be furnished as directed.

3.5 Accuracy

Unless indicated by the lead range, antenna radiation pattern data will be accurate to ± 1.0 dB as referenced to the absolute gain of an isotropic antenna.

3.7 Antenna Pattern Requirements

The requirements for antenna patterns can be found in the following subparagraphs.

3.7.1 Formats. Data described here is only acceptable in DOS format on an IBM-compatible floppy disk and a computer printout.

3.7.2 Antenna Radiation Pattern Data. The minimum antenna polarization component parameters for all data submissions are g_{RH} , g_{LH} , and δ' (or τ) or g_{RH} , g_{LH} , g_{θ} , and g_{45} or g_{RH} , g_{LH} , g_{θ} , g_{45} , and g_{135} . An absolute isotropic reference value must be provided with the gain values g_{θ} , g_{ϕ} , g_{45} , and g_{135} for DOS disk.

3.7.3 Test Report. This test report is a general outline of information that should accompany range user's DOS disk when the range user modifies or builds a new antenna, makes an antenna-configuration change, or changes antenna location, so antenna characteristics can be evaluated.

3.7.3.1 General Description. This paragraph describes the launch program to which the data applies, the frequency at which the antenna-pattern measurements were taken, the terminal power level of the transmitter antenna system in dBm, and the minimum power level required (with accuracy estimate) at the receiver antenna terminals in dBm.

3.7.3.2 Link Analysis Summary. This section identifies the instrumentation sensor (characteristics) used for any calculations, antenna gains, polarizations, transmit power, cable losses, free space path loss, and any other required information. The equation for calculating free space path loss is

$$L_p \text{ (dB)} = 36.57 + 20 \log [\text{SR (miles)} * F \text{ (MHz)}]$$

or

$$L_p \text{ (dB)} = 87.56 + 20 \log [\text{SR (km)} * F \text{ (Hz)}]$$

$$L_p \text{ (dB)} = \text{free space path loss}$$

$$\text{SR(mi or km)} = \text{statute miles or slant range in kilometers}$$

$$F(\text{Hz or MHz}) = \text{frequency in Hz or MHz}$$

3.7.3.3 Block Diagram. In this section, provide an electrical block diagram of the antenna system. The block diagram should include cables, multicouplers, or any other devices between the transmitter and antenna or antenna and receiver. In addition, a block diagram of the test equipment configuration should be furnished.

3.7.3.4 Vehicle Model Description. In this section, describe the airborne vehicle model (when used) by identifying the physical location of the antenna on the vehicle and by using the spherical-coordinate system and the vehicle-station indicators. In the event the antenna system consists of more than one antenna element, the location of each element is required.

3.7.3.5 Photographs. It is always helpful to have photographs of the airborne vehicle model (if used), the antenna test range, test antennas, antenna positioner, and any other miscellaneous items.

3.7.3.6 Antenna Range Description. A general description should be given of the antenna-test range, type, antenna positioner, length, and any other special characteristics.

3.7.3.7 Abbreviations. A list of appropriate abbreviations used in the test report must be provided.

3.7.3.8 Calibration Data. This section is used to document the data needed to make the modification to uncorrected antenna data. The data would include test antenna and system loss.

3.7.3.8.1 Antenna Test. Test the antenna (or transmitting) power gain, beamwidth, polarization, and size.

3.7.3.8.2 System Losses. Include loss of lines, losses resulting from standing waves or impedance mismatches, loss of multicoupler, or any loss that decreases the power level between the transmitter and antenna. Phasing networks and couplers associated with antenna arrays are considered part of the antenna system. Losses in these elements and antenna inefficiency must be included in the antenna pattern as part of the pattern measurement.

3.7.3.9 Antenna Specifications. In this paragraph, document minimum antenna specifications for power gain, directivity, efficiency, and coverage determined from link analysis.

3.7.3.10 Analysis Summary. Provide an antenna analysis comparing the antenna's actual measured efficiency to the minimum specified that was used in the link analysis for power gain, directivity, efficiency, coverage, and phase requirement (when required).

3.7.3.11 Disk Description. Each disk's identification label must describe the different frequencies and antenna configurations (see subparagraph 4.2.5, More Than One Antenna System Per Disk).

CHAPTER 4

MAGNETIC MEDIUM FORMAT

4.1 General Specifications

The only acceptable magnetic medium is a DOS-formatted 3-1/2 or 5 1/4-inch low or high density, double-sided, floppy disk. The producer of the floppy disks must format and label as prescribed in this document. To save on the amount of space and disks used, file compression programs are recommended. At a later date, the files can be expanded onto a hard drive.

The 30 SPW/RF Measurements Laboratory is preparing software for analysis and graphic presentations. The PC-based software will be capable of directly interfacing with the data described in this standard. A copy of preliminary software will be available to range users after 1 March 1993. For a copy, contact ITT/Federal Services Corporation, RF Measurements Laboratory, Field Test Branch, Mail Code RS390, P.O. Box 5728, Vandenberg Air Force Base, California, 93437, ATTN: Mr. Chris Sniderhan, Commercial: (805) 734-8232, extension 6-0153 or 6-3326.

4.2 Terms and Descriptions

The magnetic medium terms and descriptions are explained in the following subparagraphs.

4.2.1 Computer Terms

4.2.1.1 ASCII. American Standard Code for Information Interchange.

4.2.1.2 Character. An alphabetic, numeric, or special character represented by 8 bits in Extended Binary-Coded Decimal Interchange Code (EBCDIC) or ASCII.

4.2.1.3 Field. A unique area of a recording reserved for a specific category of data. There are two types of data: numeric and nonnumeric.

4.2.1.4 Record. A collection of fields.

4.2.1.5 File. A collection of related records treated as a unit followed by an end-of-file mark.

4.2.1.6 Fixed Point. Positive or negative real numbers that contain decimal points.

4.2.1.7 Delimiter. A character that marks the beginning or end of a data unit on a stored medium. Commas, semicolons, periods, and spaces are used as delimiters to separate and to organize data items.

4.2.2 Information File (Filename.TXT). An ASCII text file used to describe the data file. It consists of 30 records, which are described in paragraph 4-3.

4.2.3 Data File (Filename.DAT). The polarization component data files written in a numeric fixed-point format for each data field with fixed record lengths (depending on the angular increment size and the type of grouping used, θ constant or ϕ constant). Only one data file is required, either for a constant θ or ϕ . The first record contains the Filename.DAT, while the second record contains the total record count of the data file. The third record of each data file must contain three values, namely W, m, and n, defined as

	ϕ Constant	θ Constant
W =	Angular increment of 1° thru 10° except 7° or 8°	
m =	$180/W + 1$	$360/W$
n =	$360/W$	$180/W + 1$

4.2.3.1 Data File Record Header Format

	<u>Field 1</u>	<u>Field 2</u>	<u>Field 3</u>
Record ₁	"XXXXXXXXX.XXX",		
Record ₂	XXXXXXXXX,		
Record ₃	XXX,	XXX,	XXX,

The data file uses commas as delimiters marking the end of each data field.

4.2.3.2 Linear Gain and Phase Data Record Format

	<u>ϕ</u>	<u>θ</u>	<u>psi</u> (See note)	<u>g</u>
Record _i	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,

Record _{nm+3}	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,
	EOF			

Note: The psi field is only required when specified by the lead range.

4.2.3.3 Polarized Gain (RHCP and LHCP) and Delta Phase Data Record Format

	<u>ϕ</u>	<u>θ</u>	<u>δ'</u>	<u>g_{RH}</u>	<u>g_{LH}</u>
Record _i	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,

Record _{nm+3}	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,
	EOF				

4.2.3.4 Linear Gain (ϕ & θ) and Phase (ϕ & θ) Data Record Format

	<u>ϕ</u>	<u>θ</u>	<u>Psi_i</u>	<u>psi₀</u>	<u>g_{ϕ}</u>	<u>g₀</u>
Record _i	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,

Record _{nm+3}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,
	EOF					

4.2.4 Disk Identification. Each disk must be identified with the following information:

- the missile program and antenna type or some unique unclassified identifier,

- disk density mode (DOS formatted) - high (1.44 M bits) or low (720 K bits),
- series identification such as disk 2 of 3 disks, and
- test date.

The identification can be a computer run number identifier, an internal work request number, or a similar identifier. Given a unique method of correlating the disk, the range can devise its own system of internal disk density mode, but the mode must be specified on the identification marker. A typical disk label is

Saturn, C-band antenna pattern data

MS-DOS 3.3 low density - 720K bits

Disk 1 of 1

3 November 1991

4.2.5 More Than One Antenna System Per Disk. Other antenna patterns may be placed on a disk provided certain criteria are followed; conventions are used in assigning names to antenna data and text files. For example:

Filename= XXXXFTTT.DAT or XXXXFTTT.TXT

XXXX= Project designator

F= Frequency

U= UHF

S= S-Band

C= C-Band

TTT= Type of data

Adj= Corrected data

Raw= Uncorrected data

HCP= Circular polarized

4.2.6 Disk Use for More Than One Pattern for a Single Antenna System. Often, more than one radiation pattern group is required from a single antenna system. This requirement may result from any factor that serves to significantly alter the antenna pattern. For example, changes in antenna radiation characteristics may be the result of variation of frequency required to be radiated from the antenna system; change in vehicle configuration (for example, at staging or separation); and variations in RF propagation characteristics such as flame and reentry plasma effects). When these conditions exist, the other pattern groups should be treated the same as patterns of separate antennas with the proper identifying description in the appropriate location in the information file.

4.3 Information File Description

The information file will be labeled Filename.TXT on the disk. The content of each information record will be

Record 1 Identification of the launch program data including the program name, PRD number and test code, missile name and test number, if any. The classified information necessary to identify the launch program will be attached to be automatically downgraded to unclassified when separated from the cover letter.

Example - Record 1 WS107A-2, Lot A, XSM-68 program, PRD 1100, Test Code B, Titan Missile A-10 Test No. 4521.

Record 2 The project office assigned to the program, the name of the contractor originating the disk, and a point of contact. Care must be taken so the combination of information does not classify the disk.

Example - Record 2 DWTB Project Office, ACE Missile Co., P.O. Box 123
ATTN: John Watson (Project Engineer)
Los Angeles, California 90045

Record 3 Identification of the instrumentation system by name or designation and function. The instrumentation is intended to be primarily range equipment.

Example - Record 3 FPS-16 Radar Transponder.

Record 4 Description of the antenna.

Example - Record 4 Antenna is a cavity type.

Record 5 Intended operating frequency of the antenna.

Example - Record 5 Operating frequency is 5466 MHz.

Record 6 thru 9 Physical location of the antenna on the vehicle spherical coordinate system in units of $^\circ$ and the vehicle station indication (normally inches from the nose). In the event the antenna system consists of more than one antenna element (2 to 10 antenna elements operating as an array), the location of each element is required. Provision has been made for multiple elements in an array. Records 6 and 7 will contain phi values in degrees, separated by commas for each element, while records 8 and 9 will contain corresponding station locations, also separated by commas, with the units and reference location noted following these values.

Example - Record 6 94, 184 274, 04 degrees phi

Example - Record 7 Not applicable.

Example - Record 8 63, 63, 63, 63 stations, second stage.

Example - Record 9 63, 63, 63, 63 stations, third stage.

Record 10 Physical location of point P'_r on the vehicle body.
 P'_r is defined as the point at which negative yaw axis pierces the vehicle skin (that is, at $\phi = 0^\circ$, $\theta = 90^\circ$).

Example - Record 10 PYPRIME is on Pod No. 1 (Pitch Plane).

Record 11 The major antenna polarization over the operating portion (in geometric space) of the antenna (such as linear, right- or left-hand circular or right- or left-hand elliptical).

Example - Record 11 Major antenna polarization is linear.

Record 12 The scale factor of the model used in getting the antenna measurements.

Example - Record 12 Model scale is one-eighth full size.

Record 13 The frequency at which the pattern measurements of model were made and whether the signal was CW or pulsed.

Example - Record 13 Measurement frequency is 5200 MHz, pulsed at 12.5 microseconds and 160 pulse repetition frequency (PRF).

Record 14 Indicate whether a constant θ or a constant ϕ was used in making the measurements. A constant θ indicates that θ is constant within a data record while ϕ varies at the delta increment within each record. The θ value increases at the delta rate through the records in the data file. A constant ϕ has the same reading except that ϕ and θ are interchanged in the preceding statement. Only one data file is required for a constant θ or ϕ , not both.

Example - Record 14 Constant theta-type measurement is used.

Record 15 Provision has been made for six polarization
Thru 20 components. Components, g_{RH} , g_{LH} , g_{ϕ} , g_{θ} , g_{45° , and g_{135° are in dB relative to an isotropic reference value provided in each record. The tilt angle τ will be calculated by the range from linear polarized amplitude components

(g_{ϕ} , g_{θ} , g_{45° , and g_{135°). Proper orientation of the E_{ϕ} and E_{θ} coordinates, and consequently g_{ϕ} and g_{θ} , in the vehicle's coordinate system is shown in figure 3-1. Subscripts on component designations E_{45° or g_{45° and E_{135° or g_{135° represent the angles at which these values are measured. Angles are measured from the positive E_{θ} axis in a counterclockwise direction. Therefore, E_{45° or g_{45° is the 45° linear component, and E_{135° or g_{135° is the 135° or minus 45° component. Figure 3-1 shows the linear component orientations in relationship to the antenna coordinate system. Accuracy values of the gain measurement should be stated in dB following the polarization mode. If accuracy changes over the range of measurement, major changes should be noted.

Record 15 Record 15 will include the right hand-circular polarization component g_{RH} .

Example - Record 15 Polarization component recorded is right-hand circular. Accuracy of gain measurement is ± 1.0 dB.

Record 16 Record 16 will include the left hand circular polarization component.

Example - Record 16 Polarization component recorded is left-hand circular. Accuracy of gain measurement is ± 1.0 dB.

Record 17 Third polarization component, g_{ϕ} .

Example - Record 17 Polarization component recorded is linear ϕ . Measurement accuracy is same as stated in record 16.

Record 18 Fourth polarization component, g_{θ} .

Example - Record 18 Polarization component recorded is linear θ . Measurement accuracy is same as stated in record 16.

Record 19 Fifth polarization component, g_{45° .

Example - Record 19 Polarization component recorded is linear 45° . Measurement accuracy is as stated in record 16.

Record 20 Sixth polarization component, g_{135} .

Example - Record 20 Polarization component recorded is linear 135° . Measurement accuracy is same as stated in record 16.

Record 21 Intended operating frequency range of the associated transmitter.

Example - Record 21 Transmitter frequency range is 5400 to 5900 MHz.

Record 22 Intended operating frequency range of the associated receiver.

Example - Record 22 Receiver frequency range is 5450 to 5895 MHz.

Record 23 Power level (with accuracy estimate) at terminals of the transmitter antenna system in dBm. The power level required is that level produced by the missile-borne transmitter at the point in the instrumentation system where the antenna radiation pattern is recorded. It can be obtained by subtracting transmission system losses from the power at the transmitter output terminals (for example, line losses, standing wave or impedance mismatch losses, multicoupler losses, or any loss that decreases the power level between the transmitter and antenna). Phasing networks and couplers associated with antenna arrays are considered part of the antenna system. Losses in these elements and antenna inefficiency must be included in the antenna pattern as part of the pattern measurement. If more than one power level must be provided, consecutive information records starting with record 23 will be used. Only one power level will be provided per record. Show average, peak, or both levels, as required, to define power characteristics of the pulse or CW signal. Provision has been made for a maximum of four power levels.

Example - Record 23 Total power level at transmitter antenna system is 54 ± 1 dBm at 5450.8 MHz.

Record 24 Power level (with accuracy estimate) at terminals of the transmitter antenna in dBm. This is the second location for possible power levels to be provided. If the record is not necessary, place "Not applicable" in the record.

Example - Record 24 Total power level at the transmitter antenna system is 58 ± 1 dBm at 5600 MHz.

Record 25 Power level (with accuracy estimate) at terminals of the transmitter antenna in dBm. This is the third location for possible power levels to be provided. If the record is not necessary, place "Not applicable" in the record.

Example - Record 25 Total power level at the transmitter antenna system is 59 ± 1 dBm at 5850 MHz.

Record 26 Power level (with accuracy estimate) at terminals of the transmitter antenna in dBm. This is the fourth location for possible power levels to be provided. If the record is not necessary, place "Not applicable" in the record.

Example - Record 26 Not applicable.

Record 27 Minimum power level required (with accuracy estimate) at the receiver antenna terminals in dBm. In determining the minimum power level, allowance must be made for such parameters as bandwidth, noise figure, required signal noise ratio, transmission line attenuation, impedance mismatch, multicoupler losses, and safety margin. The amount desired is the minimum power level (dBm) required at the receiver input plus the various losses (dB) from the antenna system to the receiver input. The value required is the minimum power level that can be tolerated for required data quality at the point in the missile-borne system where the antenna radiation pattern is recorded. Phasing networks and couplers associated with antenna arrays are considered part of the antenna system. Losses in these elements and antenna inefficiencies should be included in the antenna pattern as part of the pattern measurement. If the minimum power level required varies by more than 2 dB over the frequency range of operation, major power levels will be provided. In all cases, at least one power level will be entered. If more than one power level must be provided, consecutive information records starting with record 27 will be used. Only one power level will be provided per record. Show average or peak level for CW or pulse system. Provision has been made for a maximum of four power levels.

Example - Record 27 Minimum power level required at the receiver antenna system is -78 ± 2 dBm at 5500 MHz.

Record 28 Minimum power level required (with accuracy estimate) at the receiver antenna terminals in dBm. If a second power level is not required, place "Not applicable" in this record.

Example - Record 28 Minimum power level required at the receiver antenna system is -75 ± 2 dBm at 5900 MHz.

Record 29 Minimum power level required (with accuracy estimate) at the receiver antenna terminals in dBm. If a third power level is not required, place "Not applicable" in this record.

Example - Record 29 Not applicable.

Record 30 Minimum power level required (with accuracy estimate) at the receiver antenna terminals in dBm. If a fourth power level is not required, place "Not applicable" in this record.

Example - Record 30 Not applicable.

4.4 Data File Description

The data file will have the same name as the information file, but have the .DAT extension. The data file will consist of the filename.DAT record count, description record, and data record.

$n = (360/W)$ for constant ϕ , and $n = (180/W) + 1$ for constant θ ,

$m = (180/W) + 1$ for constant ϕ , and $m = (360/W)$ for constant θ , and

$W =$ is the angular increment of ϕ and θ used in making the measurements and must be the same for both ϕ and θ .

4.4.1 Constant θ File Description. Type recording and the description record will have the following format:

$\theta = \theta$ (θ varies from 0 to 180° in increments of W in the data file). $\phi = \phi$ (ϕ varies from 0 to 360° in increments of W in the data file).

Record 1 Filename

Field 1 Filename.DAT

Record 2 Record Count

Field 1 Integer value ($W = nm + 3$)

Record 3 Description Record

Field 1 Integer value of W increment

Field 2 Integer m value ($m=360/W$)

Field 3 Integer n value ($n=(180/W)+1$)

Record 4 All data record fields are assigned to Record numeric fixed point values. Psi (delta), nm+3 Φ (phi) and Θ (theta) are measured in degrees, while $g_{(RH, LH, \Phi, \Theta, 45^\circ, \text{ or } 135^\circ)}$ is in dB. The psi field is only required when specified by the lead range. See tables 4-1, 4-3, 4-5, or 4-7 for data file examples (Φ held at successive constants).

4.4.2 Constant Φ File Description. The constant Φ type example is

$\Phi = \Phi$ (Φ varies from 0 to 180° in increments of W in the data file). $\Theta = \Theta$ (Θ varies from 0 to 360° in increments of W in the data file).

Record 1 Filename

Field 1 Filename.DAT

Record 2 Record Count

Field 1 Integer value ($W=nm+3$)

Record 3 Description Record

Field 1 Integer value of W increment

Field 2 Integer m value ($m=(180/W)+1$)

Field 3 Integer n value ($n=360/W$)

Record 4 All data record fields are assigned to Record fixed point values. Psi, Φ , and Θ are nm+3 measured in degrees, while $g_{(RH, LH, \Phi, \Theta, 45^\circ, \text{ or } 135^\circ)}$ is in dB. The psi field is only required when specified by the lead range. See tables 4-2, 4-4, 4-6, or 4-8 for data file examples (Φ held at successive constants).

4.5 Sample Information File

The following example contains the type of information that might typically be included in the information file:

- Record 1 WS107A-2, Lot A, XSM-68 program PRD 1100. Test Code B, Titan Missile A-10, Test No. 4321.
- Record 2 DWTB Project Office, ACE Missile Co., P.O. Box 123, Los Angeles, California 90045, John Watson, Project Engineer.
- Record 3 FPS-16 Radar Beacon
- Record 4 Antenna is a cavity type
- Record 5 Operating frequency is 5466 MHz.
- Record 6 94, 184 274, 04° phi
- Record 7 Not applicable.
- Record 8 63, 63, 63, 63 stations, second stage.
- Record 9 63, 63, 63, 63 stations, third stage.
- Record 10 PYPRIME is on Pod No. 1 (Pitch Plane).
- Record 11 Predominant antenna polarization is linear.
- Record 12 Model scale is one-eighth full size.
- Record 13 Measurement frequency is 5200 MHz.
- Record 14 Constant theta-type measurement is used.
- Record 15 Polarization component recorded is right-hand circular. Accuracy of gain measurement is ± 0.5 dB as referenced to an isotropic antenna.
- Record 16 Polarization component recorded is left-hand circular. Accuracy of gain measurement is ± 0.5 dB as referenced to an isotropic antenna.
- Record 17 Polarization component recorded is linear phi. Measurement accuracy is same as stated in record 15.
- Record 18 Polarization component recorded is linear theta. Measurement accuracy is same as stated in record 15.

- Record 19 Polarization component recorded is linear 45°. Measurement accuracy is same as stated in record 15.
- Record 20 Polarization component recorded is linear 135°. Measurement accuracy is same as stated in record 15.
- Record 21 Transmitter frequency range is 5400 to 5900 MHz.
- Record 22 Receiver frequency range is 5450 to 5895 MHz.
- Record 23 Total power level at transmitter antenna system is +54±1 dBm at 5450.8 MHz.
- Record 24 Total power level at the transmitter antenna system is +58±1 dBm at 5600 MHz.
- Record 25 Total power level at the transmitter antenna system is +59±1 dBm at 5850 MHz.
- Record 26 Not applicable.
- Record 27 Minimum power level required at the receiver antenna system is -78±2 dBm at 5500 MHz.
- Record 28 Minimum power level required at the receiver antenna system is -75±2 dBm at 5900 MHz.
- Record 29 Not applicable.
- Record 30 Not applicable.

TABLE 4-1. LINEAR GAIN AND PHASE DATA FILE EXAMPLE.
THETA HELD AT SUCCESSIVE CONSTANTS

	Field 1	Field 2	Field 3	Field 4	Description
Record 1	"XXXXXXXXX.XXX",				Filename
Record 2	XXXXXXXXXX,				Record Count =nm+3
Record 3	XXX,	XXX,	XXX,	XXX.XX,	W, n, m
Record 4	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=0, \theta=0, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=W, \theta=0, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=2W, \theta=0, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=3W, \theta=0, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=(i-1)W, \theta=0, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=0, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=0, \theta=W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=W, \theta=W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=2W, \theta=W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=3W, \theta=W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=(i-1)W, \theta=W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=0, \theta=2W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=W, \theta=2W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=2W, \theta=2W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=3W, \theta=2W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=(i-1)W, \theta=2W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=2W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=0, \theta=3W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=W, \theta=3W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=2W, \theta=3W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=3W, \theta=3W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=(i-1)W, \theta=3W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=3W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=0, \theta=(i-1)W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=W, \theta=(i-1)W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=2W, \theta=(i-1)W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=3W, \theta=(i-1)W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=(i-1)W, \theta=(i-1)W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=(i-1)W, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=0, \theta=180^\circ, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=W, \theta=180^\circ, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=2W, \theta=180^\circ, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=3W, \theta=180^\circ, \text{Psi}, g$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=(i-1)W, \theta=180^\circ, \text{Psi}, g$
Record nm+3	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=180^\circ, \text{Psi}, g$
EOF					

NOTE: g is equal to $g(\text{RH}, \text{LH}, \phi, 45^\circ, \text{ or } 135^\circ)$.

TABLE 4-2. LINEAR GAIN AND PHASE DATA FILE EXAMPLE.
PHI HELD AT SUCCESSIVE CONSTANTS

	Field 1	Field 2	Field 3	Field 4	Description
Record1	XXXXXXXXXX.XXX,				Filename
Record2	XXXXXXXXXX,				Record Count =nm+3
Record3	XXX,		XXX,	XXX.XX,	W, n, m
Record4	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=0, 0=0, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=0, 0=W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=0, 0=2W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=0, 0=3W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=0, 0=(i-1)W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=0, 0=360°-W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=W, 0=0, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=W, 0=W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=W, 0=2W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=W, 0=3W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=W, 0=(i-1)W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=W, 0=360°-W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=2W, 0=0, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=2W, 0=W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=2W, 0=2W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=2W, 0=3W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=2W, 0=(i-1)W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=2W, 0=360°-W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=3W, 0=0, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=3W, 0=W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=3W, 0=2W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=3W, 0=3W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=3W, 0=(i-1)W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=3W, 0=360°-W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=(i-1), 0=0, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=(i-1)W, 0=W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=(i-1)W, 0=2W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=(i-1)W, 0=3W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=(i-1)W, 0=(i-1)W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=(i-1)W, 0=360°-W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=180°, 0=0, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=180°, 0=W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=180°, 0=2W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=180°, 0=3W, Psi, g
Recordj+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=180°, 0=(i-1)W, Psi, g
Recordnm+3	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	0=180°, 0=360°-W, Psi, g
EOF					

NOTE: g is equal to 9(RH, LH, 0, 0, 45°, or 135°).

TABLE 4-3. LINEAR GAIN DATA FILE EXAMPLE. THETA HELD AT SUCCESSIVE CONSTANTS

	Field 1	Field 2	Field 3	Description
Record ₁	"XXXXXXXXX.XXX",			Filename
Record ₂	XXXXXXXXXX,			R-cord Count =nm+3
Record ₃	XXX,		XXX,	W, n, m
Record ₄	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=0, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=0, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=0, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-2)W, \theta=0, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \theta=0, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=(i-1)W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \theta=(i-1)W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=(i-1)W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=(i-1)W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \theta=(i-1)W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=180^\circ, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \theta=180^\circ, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=180^\circ, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=180^\circ, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \theta=180^\circ, g$
Record _{nm+3}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \theta=180^\circ, g$
EOF				

NOTE: g is equal to g(RH, LH, θ , θ , 45° , or 135°).

TABLE 4-1. LINEAR GAIN DATA FILE EXAMPLE. PHI HELD AT SUCCESSIVE CONSTANTS

	Field 1	Field 2	Field 3	Description
Record ₁	"XXXXXXXXXX.XXX",			Filename
Record ₂	XXXXXXXXXX,			Record Count =nm+3
Record ₃	XXX,		XXX,	W, n, m
Record ₄	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=0, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=C, \theta=(i-1)W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \theta=360^\circ-W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \theta=(i-1)W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \theta=360^\circ-W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=0, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=(i-1)W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \theta=360^\circ-W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=0, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=(i-1)W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \theta=360^\circ-W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1), \theta=0, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \theta=(i-1)W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \theta=360^\circ-W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=180^\circ, \theta=0, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=180^\circ, \theta=W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=180^\circ, \theta=2W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=180^\circ, \theta=3W, g$
Record _{j+1}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=180^\circ, \theta=(i-1)W, g$
Record _{nm+3}	XXX.XX,	XXX.XX,	XXX.XX,	$\theta=180^\circ, \theta=360^\circ-W, g$
EOF				

NOTE: g is equal to g(RH, LH, θ , θ , 45°, or 135°).

TABLE 4-5. POLARIZED GAIN (RHCP & LHCP) AND DELTA PHASE DATA FILE EXAMPLE.
THETA HELD AT SUCCESSIVE CONSTANTS

	Field 1	Field 2	Field 3	Field 4	Field 5	Description
Record 1	XXXXXXXXXX.XXX",					Filename
Record 2	XXXXXXXXXX,					Record Count =nm+3
Record 3	XXX,	XXX,	XXX,	XXX.XX,	XXX.XX,	W, n, m
Record 4	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=0, \theta=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=W, \theta=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=2W, \theta=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=3W, \theta=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=(1-1)W, \theta=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=0, \theta=W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=W, \theta=W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=2W, \theta=W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=(1-1)W, \theta=W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=0, \theta=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=W, \theta=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=3W, \theta=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=(1-1)W, \theta=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=0, \theta=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=W, \theta=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=2W, \theta=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=(1-1)W, \theta=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=0, \theta=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=W, \theta=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=2W, \theta=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=3W, \theta=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=(1-1)W, \theta=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=0, \theta=180^\circ, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=W, \theta=180^\circ, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=2W, \theta=180^\circ, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=3W, \theta=180^\circ, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=(1-1)W, \theta=180^\circ, \delta', 9RH, 9LH$
Record nm+3	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\phi=360^\circ-W, \theta=180^\circ, \delta', 9RH, 9LH$
EOF						

TABLE 4-6. POLARIZED GAIN (RHCP & LHCP) AND DELTA PHASE DATA FILE EXAMPLE.
PHI HELD AT SUCCESSIVE CONSTANTS

	Field 1	Field 2	Field 3	Field 4	Field 5	Description
Record 1	"XXXXXXXXX.XXX",					Filename
Record 2	XXXXXXXXXX,					Record Count =nm+3
Record 3	XXX,	XXX,	XXX,	XXX.XX,	XXX.XX,	W, n, m
Record 4	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0, \Phi=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W, \Phi=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W, \Phi=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W, \Phi=C, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W, \Phi=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W, \Phi=0, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=C, \Phi=W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W, \Phi=W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W, \Phi=W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W, \Phi=W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W, \Phi=W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0, \Phi=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W, \Phi=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W, \Phi=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W, \Phi=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W, \Phi=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W, \Phi=2W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0, \Phi=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W, \Phi=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W, \Phi=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W, \Phi=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W, \Phi=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W, \Phi=3W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0, \Phi=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W, \Phi=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W, \Phi=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W, \Phi=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W, \Phi=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W, \Phi=(1-1)W, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0, \Phi=180^\circ, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W, \Phi=180^\circ, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W, \Phi=180^\circ, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W, \Phi=180^\circ, \delta', 9RH, 9LH$
Record j+1	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W, \Phi=180^\circ, \delta', 9RH, 9LH$
Record nm+3	XXX.XX,	XXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W, \Phi=180^\circ, \delta', 9RH, 9LH$
EOF						

TABLE 4-7. LINEAR GAIN (Φ & Θ) AND PHASE (Φ & Θ) DATA FILE EXAMPLE.
THETA HELD AT SUCCESSIVE CONSTANTS

	Φ Field 1	0 Field 2	Psi Field 3	Psi Field 4	Θ Field 5	Θ Field 6	Description
Record ₁	"XXXXXXXXX.XXX",						Filename
Record ₂	XXXXXXXXXX,						Record Count =nm+3
Record ₃	XXX,	XXX,	XXX,	XXXX.XX,	XXX.XX,	XXX.XX,	W, n, m
Record ₄	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0$, $\Theta=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W$, $\Theta=U$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W$, $\Theta=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W$, $\Theta=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W$, $\Theta=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W$, $\Theta=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0$, $\Theta=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W$, $\Theta=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W$, $\Theta=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W$, $\Theta=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W$, $\Theta=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W$, $\Theta=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0$, $\Theta=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W$, $\Theta=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W$, $\Theta=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W$, $\Theta=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W$, $\Theta=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W$, $\Theta=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0$, $\Theta=3W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W$, $\Theta=3W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W$, $\Theta=3W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W$, $\Theta=3W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W$, $\Theta=3W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0$, $\Theta=(1-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W$, $\Theta=(1-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W$, $\Theta=(1-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W$, $\Theta=(1-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W$, $\Theta=(1-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W$, $\Theta=(1-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=0$, $\Theta=180^\circ$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=W$, $\Theta=180^\circ$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=2W$, $\Theta=180^\circ$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=3W$, $\Theta=180^\circ$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=(1-1)W$, $\Theta=180^\circ$
Record _{nm+3}	XXX.XX	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\Theta=360^\circ-W$, $\Theta=180^\circ$

EOF

TABLE 4-8. LINEAR GAIN (ϕ & θ) AND PHASE (ϕ & θ) DATA FILE EXAMPLE.
PHI HELD AT SUCCESSIVE CONSTANTS

	ϕ Field 1	θ Field 2	Psi Field 3	Psi Field 4	θ Field 5	ϕ Field 6	Description
Record ₁	"XXXXXXXXX.XXX",						Filename
Record ₂	XXXXXXXXXX,						Record Count =nm+3
Record ₃	XXX,	XXX,	XXX,	XXXX.XX,	XXX.XX,	XXX.XX,	W, n, m
Record ₄	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \phi=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \phi=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \phi=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \phi=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \phi=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \phi=0$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \phi=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \phi=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \phi=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \phi=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \phi=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \phi=W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \phi=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \phi=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \phi=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \phi=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \phi=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \phi=2W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \phi=3W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \phi=3W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \phi=3W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \phi=3W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \phi=3W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \phi=(i-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \phi=(i-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \phi=(i-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \phi=(i-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \phi=(i-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \phi=(i-1)W$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=0, \phi=180^\circ$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=W, \phi=180^\circ$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=2W, \phi=180^\circ$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=3W, \phi=180^\circ$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=(i-1)W, \phi=180^\circ$
Record _{j+1}	XXX.XX,	XXX.XX,	XXXX.XX,	XXXX.XX,	XXX.XX,	XXX.XX,	$\theta=360^\circ-W, \phi=180^\circ$
Record _{nm+3}							
EOF							